Impact of Land Cover Data on Atmospheric Processes and Air Quality

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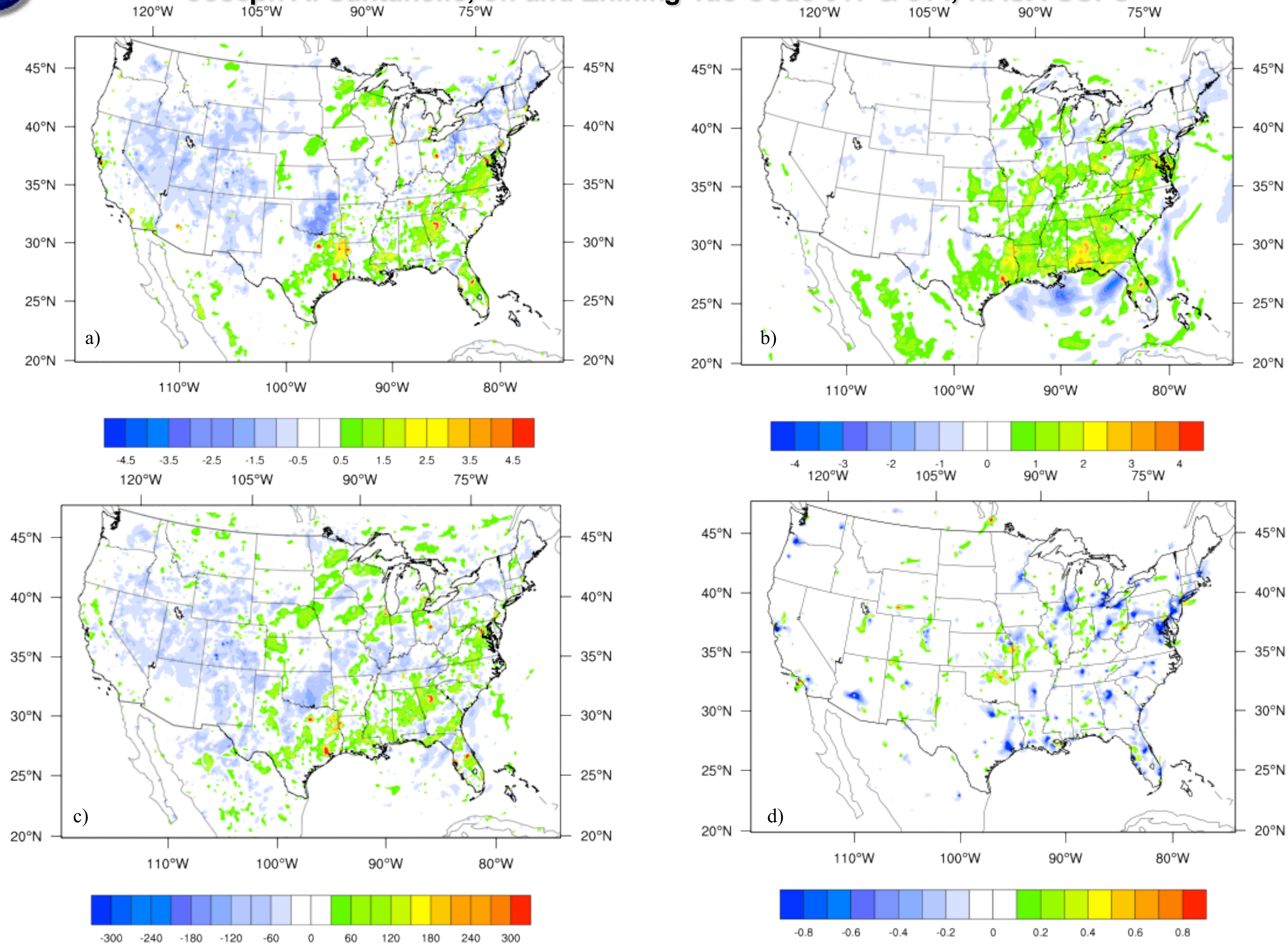

Figure. 1: Differences in **a)** 2-meter air temperature, **b)** ozone concentration, **c)** PBL height, and **d)** NO2 concentration from the MODIS and USGS land cover-based NU-WRF simulations averaged over the CalNex case study period.

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Land cover and vegetation type play a critical role in modulating water and energy fluxes at the land-atmosphere interface. The subsequent **formation and transport of primary and secondary pollutants** through the planetary boundary layer (PBL) are therefore sensitive to the land cover classification specified in coupled models.

In this study, we examine the impact of different satellite-derived land cover datasets on **predictions of air quality and meteorology over the continental United States** using the **NASA Unified-WRF (NU-WRF)** regional model coupled to **NASA's Land Information System (LIS)**. Simulations were run during the CalNex field experiment in May-June 2010.

References:

• Tao, Zhining et al., J. Santanello, M. Chin, and C. Peters-Lidard, 2012: Effect of Land Cover on Atmospheric Processes and Air Quality. In prep.
• Santanello, J. A., C. Peters-Lidard, A. Kennedy, and S. Kumar, 2012: Diagnosing the Nature of Land-Atmosphere Coupling During the 2006-7 Dry/Wet Extremes in the U. S. Southern Great Plains. *J. Hydromet.,* under review.

Data Sources: The community-supported Weather Research and Forecasting (WRF) model has been coupled to NASA-GSFC's Land Information System (LIS) within the NASA Unified WRF (NU-WRF) system (C. Peters-Lidard and M. Chin; Co-PIs), which provides a flexible and high-resolution representation and initialization of land surface physics and states and integrates across GSFC assets in microphysics, radiation, chemistry (GOCART) schemes at satellite-scales. LIS includes a suite of land surface models (e.g. Noah LSM as used here) with an array of land cover data options. This includes the United States Geological Survey (USGS) 1993 land cover classification based on AVHRR data, the University of Maryland 1999 land cover based on AVHRR data, and the NCEP expanded land cover classification based on MODIS data (Collection 4; 2004). LIS was run offline for 3.5 years prior to initialization of each NU-WRF experiment on 26 May 2010. Emissions were calculated from the 2005 National Emissions Inventory for anthropogenic emissions, GOCART for dust and sea salt emissions, and MEGAN2 for biogenic emissions.

Technical Description of Image:

	USGS %	UMD %	MODIS %
Urban	0.070	0.93	2.40
Evergreen NL	9.480	5.34	5.38
Evergreen BL	1.768	1.48	1.16
Deciduous NL	1.608	1.26	0.76
Deciduous BL	5.842	5.15	4.51
Mixed Forest	7.212	6.59	8.00
Grassland	9.022	11.79	13.31
Bare Soil	0.173	1.24	1.01
Cropland	8.914	10.04	10.57

Table 1: Areal coverage of USGS, UMD, and MODIS based land cover classes over the continental U.S.

Table 1: Areal coverage (percent) of land cover classes derived from the USGS, UMD, and MODIS land cover classifications, and differences in ozone and NO2 concentrations from using MODIS vs. USGS land cover. Native 1km data of each was aggregated to the 20km domain of LIS and NU-WRF.

Figure 1: Difference in NU-WRF simulated fields of a) 2-meter temperature, b) ozone concentrations, c) PBL height, and d) NO2 concentrations using MODIS vs. USGS land cover data. Simulations were run for 10 days in early June 2010 over the U.S. during the CALNEX field campaign, and each field is averaged over the full period from hourly output.

Scientific significance:

- Ozone near the Earth surface is one of the criteria pollutants. It is not directly emitted from natural or anthropogenic activities, but rather is formed in the atmosphere through a complex photochemistry process in presence of oxides of nitrogen (NOx) and volatile organic compounds (VOCs). Typically, strong solar radiation and high temperatures associated with the stagnant high pressure system favors ozone formation. Higher temperatures in the eastern US (Fig. 1a) simulated using the MODIS land cover contribute to the higher ozone found there (Fig. 1b).

- NO2 is also a criteria pollutant and one of the ozone precursors. It is a primary pollutant with large anthropogenic sources. A deeper boundary layer (Fig. 1c) generally leads to a diluted concentration due to well mixing in larger volume. This contributes to the lower NO2 concentration simulated with the MODIS land cover in major urban areas (Fig. 1d) in the US where larger PBL height is simulated.

Relevance for future science and relationship to Decadal Survey: Coupled weather and climate models typically treat land cover data as a given and fixed boundary condition. As increasing complexity and components (e.g. emissions, chemistry, and hydrology) are incorporated into such models, the importance of the vegetation classification becomes even more significant. The higher spatial resolution and expanded classification (e.g. of urban areas) from the more recent MODIS product (2004) shows shifts in land cover and land use from the 1992-3 AVHRR era, and highlights the need for more frequent and detailed updating of such satellite-derived products in the future. The continuity of Landsat and MODIS missions is therefore essential in this regard.

Water discharge estimates from large radar altimetry datasets in the Amazon basin

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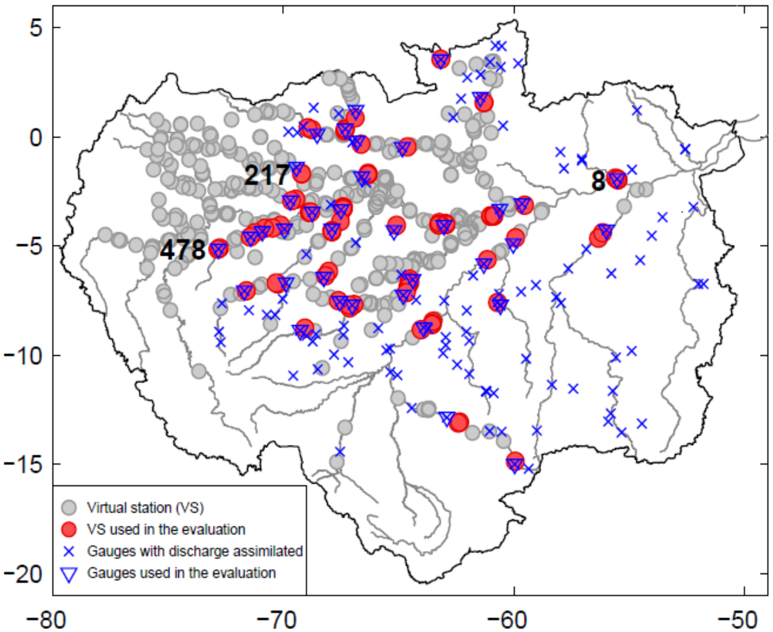

Figure 1: The Amazon basin and the geographical location of virtual stations used in this study.

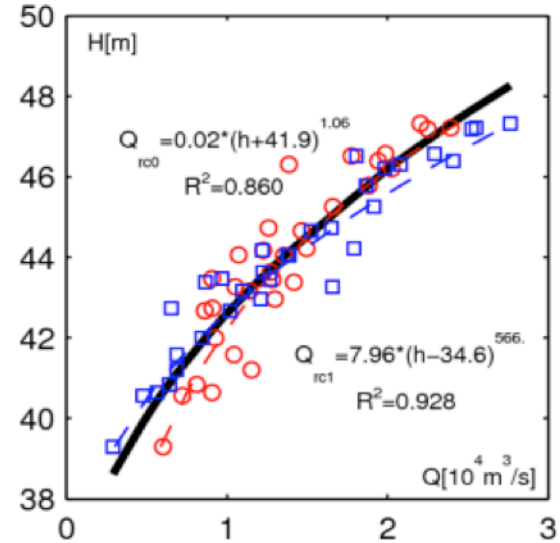

Figure 2: Experimental rating curve derived for VS-217. Red symbols indicate experiment 1 and blue symbols indicate experiment 2.

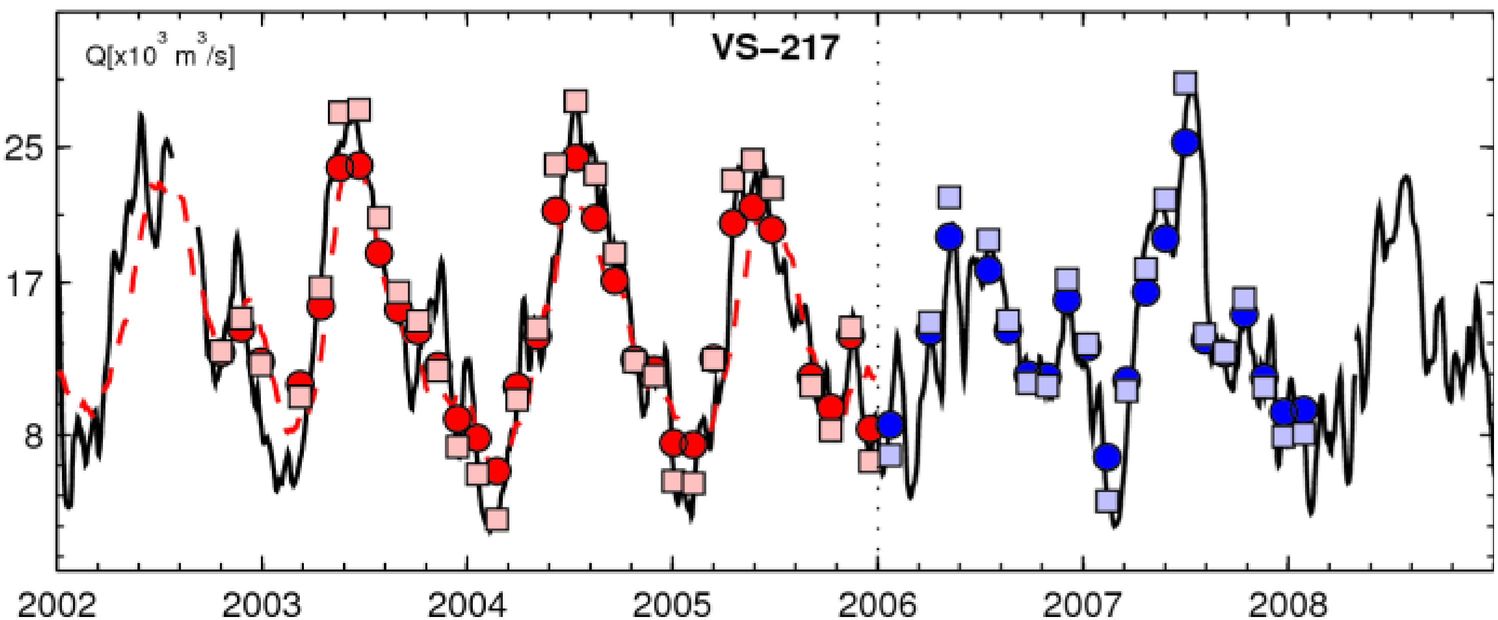

Figure 3: Observed and simulated discharges (observations and FRS outputs are in black and in ticked red lines, respectively) and Envisat estimates (red and blue symbols) at VS-217. The red symbols are from the calibration period, and the blue symbols are from the validation period. The dark and light colors represent experiments 1 and 2, respectively.

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This work presents a new methodology to predict water discharges from radar altimetry data in the Amazon basin. The technique is based on the use of a flow routing scheme (FRS) to determine rating curves (i.e. the relationship between discharge and water levels or "stages") at various locations in the basin.

References:

Getirana, A. C. V. and Peters-Lidard, C.: Water discharge estimates from large radar altimetry datasets in the Amazon basin, Hydrol. Earth Syst. Sci. Discuss., 9, 7591-7611, doi:10.5194/hessd-9-7591-2012, 2012.

Getirana, A. C. V., Bonnet, M. P., Roux, E., Calmant, S., Rotunno Filho, O. C., and Mansur, W. J.: Hydrological monitoring of large poorly gauged basins: a new approach based on spatial altimetry and distributed rainfall-runoff model, J. Hydrol., 379, 205–219, doi:10.1016/j.jhydrol.2009.09.049, 2009.

Data Sources: HyMAP routing scheme. Meteorological dataset provided by the Princeton University on a 3-hourly time step and at a 1° resolution and corrected monthly with the GPCC Full Data Product V4. Daily discharge observations are provided by the Brazilian Water Agency. ENVISAT radar altimetry data provided by downloaded on line (http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/Page_2.html).

Technical Description of Figures:

Figure 1: The Amazon basin and the geographical location of virtual stations used in this study.

Figure 2: Experimental rating curve derived for VS-217. Red symbols indicate experiment 1 and blue symbols indicate experiment 2.

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Scientific significance:
The methodology described in the paper allows us to estimate discharge from radar altimetry data. The main contribution of the paper is the quantification of the error in the discharge estimates from a large radar altimetry dataset using such methodology.
The method is quite robust and requires river flow modeling to calibrate the rating curves at virtual stations. But once the rating curves are calibrated for a given period, discharge can be measured from space at the same virtual stations with future altimetric observations provided by the satellite.

Relevance for future science and relationship to Decadal Survey:
Although the methodology was developed for radar altimetry, it can be readily applied to the interferometric SAR data from the future Surface Water Ocean Topography mission. By combining the mission data with a calibrated model, we can take advantage of model-based skill in estimating discharge from the water surface elevation measurements.